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Effect of composting *Lantana camara* weed and Farmyard manure on yield and yield components of Teff at Northern Ethiopia Tahtay Koraro district

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ABSTRACT

Introduction: *Lantana camara* makes available huge nitrogen rich moist biomass, which has potential to be utilized as a substrate for organic recycling. Its biomass has potential for utilization as organic manure, has antimicrobial, insecticidal and medicinal properties. Similarly, *Lantana camara* is one of the most widely occurring shrubs that have shown alarming growth in recent years, in our mandate areas especially in shire, Axum and Adwa. However, the complete eradication of this weed without further use of its biomass is very difficult and costly.

Objective: The objective of this study was to evaluate the effect different rates of lantana sources on teff yield and yield components.

Methodology: The experimental design was a randomized complete block design (RCBD) with seven treatments and two replicates for three years. The Lantana weed was collected from different surrounding a town called Shire which is located at north western zone of Tigray. The treatments consist of T1 (Control), T2 (Vermicompost), T3 (Dry Lantana Manure), T4 (Conventional Compost), T5 (Farmyard manure), T6 (Fresh Lantana Manure) and T7 (Lantana Compost).

Results: The application of lantana manures accelerated the days to 50% heading and days to 90% maturity, indicating improved nutrient availability and reduced stress. Plant height and panicle length were significantly enhanced with the use of lantana composts, with mixed compost and lantana vermicompost showing the most substantial improvements. Biomass and grain yields were significantly higher in plots treated with lantana-based manures compared to control plots.

Conclusions: *Lantana camara* compost enhances production and productivity of teff crop in the study area.

Recommendations: *Lantana camara* weed can be eradicated or minimized its expansion by using lantana as vermicompost and compost.

Keywords: Lantana manure; Vermicompost; Teff crop; Agronomic data; Soil properties; Biomass yield; Grain yield; Soil pH; Total nitrogen.

1. Introduction

The use of manure has generally declined on many farms due to increasing separation of crop and livestock production, cost of transporting manure, relatively low nutrient content, and increased availability of high synthetic fertilizers that usually provide a cheaper source per unit of nutrient than manure [1]. Despite these limitations, manure (and other organic nutrient sources) produced on or near a vegetable farm provide many benefits and should be beneficially utilized whenever possible. Manure and compost not only supply many nutrients for crop production, including micro nutrients, but they are also valuable sources of organic matter [2]. Increasing soil organic matter increases the water holding capacity of coarse-textured sandy soils, improves drainage in fine-textured clay soils, provides a source of slow release nutrients, reduces wind and water erosion, and promotes growth of earthworms and other beneficial soil organisms [3]. Most vegetable crops return small amounts of crop residue to the soil, so manure, compost, and other organic amendments help maintain soil organic matter levels.

Lantana camara is a multi-stem, deciduous, straggly branched shrub, with a high degree of tolerance for adverse environmental conditions. Its hardiness and high growth rate has made it one of the most aggressive biological invaders. It tends to form dense and impenetrable thickets in degraded lands, pastures, and edges of forests [4],[5]. Lantana threatens habitats and native flora and fauna. It also infests pastures, grazing lands, orchards and crops like,

tea, coffee, oil palm, coconut and cotton, and reduces the economic viability of the crops. Direct incorporation of their green matter in soil causes poor germination of seed and reduction in crop yields. Because of its invasiveness and potential for spread, it is reckoned as one of the world's most intransigent weeds [6],[7]. The microbial population was also increased and the population of actinomycetes indicated the maturity of composts. And from these results it could be stated that Lantana can be a potential source for vermicomposts production for sustainable agriculture.

However, the recycling of this weed as composted manures is the only way to avoid their nuisance; pollution effect and leading to their optimum use [8]. *Lantana camara* makes available huge nitrogen rich moist biomass, which has potential to be utilized as a substrate for organic recycling. .

Its biomass has potential for utilization as organic manure, has antimicrobial, insecticidal and medicinal properties [9]. Similarly *Lantana camara* is one of the most widely occurring shrubs that have shown alarming growth in recent years, in our mandate areas especially in shire, Axum and Adwa. The complete eradication of this weed without further use of its biomass is very difficult and costly. In addition, the green matters of lantana have tremendous potential for being used as organic manures.

1.1. Study Objective

The objective of this study was to evaluate the effect different rates of lantana sources on teff yield and yield components.

2. Methodology

The field experiment was conducted for 2015-2017 main cropping season under rain fed conditions at farmer's field in Tahtay Koraro (T/koraro), North western Zone of Tigray Regional State. T/koraro district is located on 38°18'45.099" E 14°3'17.535"N. The District altitude varies is the dominant soil types in the area. The area has crop-dominated mixed crop-livestock farming system.

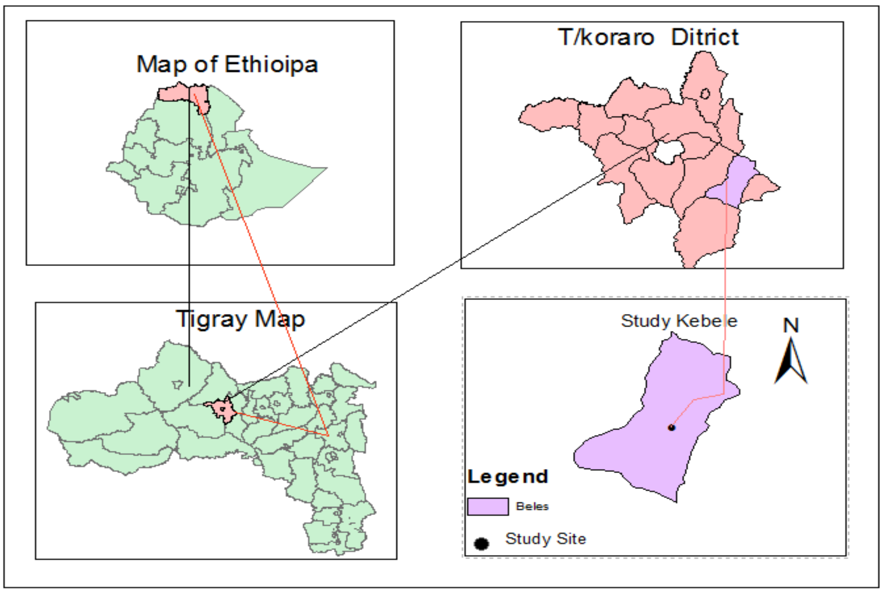

Figure 1. Map of the study area

2.1. Soil Sampling and analysis

Soil samples were collected from the experimental site at 0-20 cm depth using auger following zigzag technique. The collected soil sample before planting was analyzed for soil texture, pH, EC, organic carbon (OC), total N, available P, and CEC. Soil pH and EC was measured potentiometrically in the supernatant suspension of a 1:2.5 soil: water mixture by using a pH meter as described by [10]. The determination of soil organic carbon was based on the Walkley-Black chromic acid wet oxidation method [11]. The Kjeldhall process as outlined by [12] was followed to determine the total nitrogen. Olsen Method (Bicarbonate extractable P) was used to extract and determine available phosphorus [13]. Determination of CEC at pH 7 was carried out with Ammonium Acetate method as described by [14].

Table 1. Selected Soil properties of the study sites

Parameters	**Selected Soil properties of Experimental Sites at year 1**		**Selected Soil properties of Experimental Sites at year 2**		**Selected Soil properties of Experimental Sites at year 3**	
	(Site 1)	(Site 2)	(Site 1)	(Site 2)	(Site 1)	(Site 2)
pH	6.34	6.81	6.66	6.56	6.34	6.56
EC(mmh)	0.4264	0.3338	0.21	0.321	0.220	0.244
Ava. P	9.202	8.821	1.847	2.35	6.988	4.016
% OC	0.902	0.902	0.558	0.452	0.673	0.966
% TN	0.0615	0.0718	0.0562	0.0459	0.0433	0.062
CEC	40.6	45.6	45	42	47.80	47.00
% Sand	22	22	18	20	23	21
% Silt	37	37	26	27	29	22
% Clay	41	41	56	53	49	57
Tex. Class	Clay	Clay	Clay	Clay	Clay	Clay

Note: EC= Electrical Conductivity; OC= Organic Carbon; Total N= Total Nitrogen; Total P= Total Phosphorus; and Total K=Total potassium.

2.2. Treatments, Composting Process and Plot Size

The experimental design was a randomized complete block design (RCBD) with seven treatments and two replicates for three years. The Lantana weed was collected from different surrounding a town called Shire which is

located at north western zone of Tigray. The treatments consists of T1 (Control), T2 (Vermicompost), T3 (Dry Lantana Manure), T4 (Conventional Compost), T5 (Farmyard manure), T6 (Fresh Lantana Manure) and T7 (Lantana Compost).

Equal amount (7t/ha) of lantana Compost (LCO), dry leaf manure (DLM), fresh lantana (FLM), and conventional compost while lantana vermicompost (4t/ha) was used as treatments. For compost lantana weeds was chopped into small pieces and dumped in 1m*2m*1m pit with the alternate layers of weed biomass, soil and dung. For the preparation of lantana vermicompost Eisenia fetida earthworms was inserted, in the pit and distributed uniformly. Lantana biomass was kept for drying as dry leaf manure (DLM). Similarly fresh lantana (FLM) weed was prepared by chopping.

2.3. Agronomic Data Collection

Agronomic data such as biomass yield, grain yield, days to 50% heading, days to 90% maturity (physiological maturity), plant height, and panicle length and harvest index were recorded at the appropriate growth stage of teff.

2.4. Statistical analysis

The data was subjected to the analysis of variance (ANNOVA) by following the standard procedure and by using SAS software analysis. After performing ANOVA, the differences between the treatment means were compared by LSD test at 5% level of significance.

Trained interviewers administered the questionnaire to patients upon discharge, and the interviews were conducted in a setting ensuring privacy and confidentiality. The principal investigators re-interviewed 10 respondents for the assessment of inter-rater reliability between investigators and interviewers. By the end of the 3 months, 96% of the sample (n=120) was completed. Ethics clearance was obtained from the Ethics Review Committee of the Postgraduate Institute of Medicine.

3. Result and discussion

3.1. Days to 50% Heading and Days to 90% Maturity

The maximum number of days to reach 50% heading was observed on the control plots than the plots treated with different lantana manures as indicated in table 2. This may indicate the application of lantana manures may that increase the matrix potential of the soil and short period of moisture content in the study area speed up heading of the crop at that period of time. This result is in line with findings of [15] who reported that early flowering with an increase in the rate of N application in rice. In contrast, Abraha [16] reported that heading was significantly delayed at the highest N fertilizer rate compared to the lowest rate on teff, wheat and barley crops, respectively. This might be due to the relative higher moisture content in his study area in which this can affect nutrient availability that can persist throughout the growth stage of the crop.

It was also observed that the application of different composts of lantana hastened significantly the days of maturity of teff plants as compared to control plots. The early maturity of plants on plots composts of lantana could be due to reduction of stress that causes forced maturity. In line with this study [17] have found that application of any rate of FYM, VC and NPK fertilizers hastened days to heading and maturity as compared to unfertilized plants.

Table 2. Means of Days to 50% heading, days to physiological maturity and plant height of teff under the effect of different lantana manure

Treatment	Days to 50% Heading (days)	Days to 90 % Maturity (days)	Plant Height (cm)	Panicle length (cm)
Control	63.16[a]	109.417[a]	90.217[b]	40.233[b]
LVC	58.4167 [b]	106.250[ab]	116.675[a]	46.400[a]
DLM	60.75[ab]	107.333[ab]	112.650[a]	46.900[a]
MixCOM	58.5[b]	105.250[b]	117.367[a]	47.817[a]
FYM	58.75[b]	106.250[ab]	114.250[a]	46.017[a]
FLM	59.75[b]	106.083[ab]	114.700 [a]	46.25[a]
LCOM	60.25[b]	108.33[ab]	106.98[a]	43.55[ab]
Mean	59.94	106.98	110.40	45.31
LSD ($P \leq 0.05$)	2.57	3.55	10.95	5.54
CV (%)	3.46	4.08	8.00	9.86

Where LVC = Lantana vermicompost; DLM= Dry lantana manure; MixCOM= mixed compost; FYM= Farmyard manure; FLM= fresh lantana manure; and LCOM= lantana compost.

3.2. Plant Height and Panicle Length

The application of different composts and manures of lantana had significantly influenced plant height (Table 2). Thus, tallest plant height was found from treatments that received mixed lantana compost plus recommended urea at 7t/ha which resulted in (117.36 cm) followed by lantana vermicompost (116.67cm) while the shortest plant (90.23 cm) was obtained from control plots, respectively. Similarly longer panicle was obtained from conventional compost while shortest panicle was from control. The perusal of the data presented in Table 1 revealed that increase in dose of *Lantana* compost up to 8 t/ha increased the height of wheat plant over the untreated control. However it remained statistically at par with the 6-10t/ha of *Lantana* compost but gave higher plant height over other treatments [18]. Further increase in dose of *Lantana* compost beyond 8t/ha decreased the plant height numerically indicating its allelopathic effect at higher doses. They also notes that Spike length of wheat increase with increase in dose of *Lantana* compost up to 8 t/ha and was statistically at par with *Lantana* compost of 4 t/ha and 6 t/ha. Further increase in dose of *Lantana* compost beyond 8 t/ha decreased the spike length significantly.

3.3. Biomass Yield and Grain yield

The application of different manures of lantana had significantly influenced biomass and grain yield (Table 3). Thus, the highest biomass (6754.8kg/ha) and grain yield (1662.4kg/ha) followed by Lantana vermicompost at 3t/ha

was found from treatments that received dry lantana manure and Conventional compost at 7t/ha respectively while the lowest biomass and grain was obtained from control plots. At the teff plants grown in plot received conventional compost 7t/ha ha^{-1} of vermicompost increased the grain yield by 57% over the control. This might be due to the high plant nutrient content of lantna leaves and litters. [19] founds *lantana* is rich in nitrogen and phosphorus and as applied per it recommend dose, it might have resulted in profuse and extensive root growth resulting in higher concentrations of grain protein [20]. Similar with this result Lantana manure when applied it is increased in grain and straw yield of maize and wheat crops. Application of Lantana green or Lantana compost along with 60kgN/ha recorded yields statistically at par with the yield obtained by the application of 90kg N/ha alone [19].

Table 3. Means of Biomass yield, Grain yield, Straw yield, and Harvest index of teff under the effect of different lantana manure

Treatment	Biomass yield (kg/ha)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest Index
Control	4214.1^{c}	1060.4^{b}	3153.78^{e}	25.278
LVC	6680.0 ^{a}	1657.8^{a}	5022.20^{a}	25.235
DLM	6754.8^{a}	1609.1^{a}	5145.66^{a}	24.83
MixCOM	6672.9a	1662.4^{a}	5010.47^{a}	25.02
FYM	6173.1^{ab}	1363.3^{ab}	4809.85^{b}	22.56
FLM	6021.2^{b}	1532.8^{a}	4488.37^{c}	26.72
LCOM	5606.9^{b}	1405.9^{ab}	4200.95^{d}	25.28
Mean	6017.58	1470.259	4547.326	19.11
LSD (P≤0.05)	628.55	381.03	190.66	5.92
CV (%)	8.42	20.90	3.38	24.99

Where LVC = Lantana vermicompost; DLM= Dry lantana manure; MixCOM= mixed compost; FYM= Farmyard manure; FLM= fresh lantana manure; and LCOM= lantana compost.

3.4. Straw Yield and Harvest Index

The application of different manures of lantana had significantly influenced straw and harvest index of teff. Thus the highest straw yield (5145.66kg/ha) and (26.72) was found from treatments that received dry lantana manure at 7t/ha and lantana vermicompost at 4t/ha respectively while the lowest straw was obtained from control plots. However, there was no significant difference among the treatments in harvest index. [21] also reported that the average yield (kg/ha) of fresh vegetation of Trigonella was highest in vermicompost 11557 kg/ha followed by conventional compost 10625 kg/ha, and Mixture of compost 10492 kg/ha, and Dry Lantana Manure 9323 kg/ha and lowest in Control 5961 kg/ha. The macro nutrients were also found to be improved in all the vermicompost of

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lantana. Hence improved Nitrogen and Phosphorus contents were found in treatments with *Lantana camara* plants + Farm wastes + Poultry manure [22]. The highest concentration of TP (10.65%), K (4.29%) and Ca (2.96%) was found in the *Eisenia fetida* mediated vermicomposed as compared to *Eudrilus euginae*. However, the nutrients contents were higher than the initial values for both the earthworms [23].

3.5. Partial Budget Analysis

To assess the costs and benefits associated with the different treatments, the partial budget technique of [24] was applied to grain yield results. According to this manual, experimental yields are often higher than the yields that farmers could expect using the same treatments. Hence, in economic calculations, the grain yield has been adjusted 10% lower than the actual yield obtained from the experimental plots to make the representative yield at the farmers' fields, [24].

The highest marginal rate of return (MRR %) (43.02) was also recorded from the application of 4 t/ha lantana vermicompost at the study area (Table 4). Therefore, application of 4t/ha lantana vermicompost is profitable and is recommended for farmers in T/koraro district and other areas with similar agro-ecological conditions.

Table 4. Partial budget analysis of different sources of organic fertilizers from lantana, and farmyard manure

Trt	Price per MD	Chopping cost (60*4md/d/t)	Transport and Application cost (3md/d/t/ha)	Production cost	Total variable cost (TVC) [Birr]	Grain yield (Kg/ha)	Adj. yield (10% less) (kg ha^{-1})	Total Revenue (TR) [Grain yield*20]	Net Revenue [TR-TVC]	MRR ratio (tvc/tr)	MRR (%)
Control	0	0	0	0	0	1060.4	954.36	21950.28	21950.28	0	0
LVC	60	720	1200	1800	3720	1657.8	1492.02	34316.46	30596.46	2.324	232.42
FYM	60	0	3360	1260	4620	1363.3	1226.97	28220.31	23600.31	D	D
FLM	60	2520	3360	0	5880	1532.8	1379.52	31728.96	25848.96	D	D
DLM	60	2520	3360	1260	7140	1609.1	1448.19	33308.37	26168.37	0.253	25.35
MixCOM	60	1260	3360	4200	8820	1662.4	1496.16	34411.68	25591.68	D	D
LCOM	60	2520	3360	8400	14280	1405.9	1265.31	29102.13	14822.13	D	D

Where LVC = Lantana vermicompost DLM= Dry lantana manure MixCOM= mixed compost FYM= Farmyard manure FLM= fresh lantana manure LCOM= lantana compost MRR= Marginal Rate of Return, and D= dominance

4. Conclusion and Future Suggestions

The study demonstrates the significant impact of various lantana-based manures and composts on soil properties and teff crop productivity. Soil pH, EC, organic carbon, total nitrogen, available phosphorus, and CEC showed variability across the three years and two sites. This indicates that soil health can be influenced positively through the application of lantana-based composts. The texture remained consistently clay, which suggests the amendments

did not alter soil texture significantly but improved its chemical properties. The application of lantana manures accelerated the days to 50% heading and days to 90% maturity, indicating improved nutrient availability and reduced stress. Plant height and panicle length were significantly enhanced with the use of lantana composts, with mixed compost and lantana vermicompost showing the most substantial improvements. Biomass and grain yields were significantly higher in plots treated with lantana-based manures compared to control plots. The highest yields were observed with dry lantana manure and conventional compost. Straw yield and harvest index were also positively affected, with dry lantana manure showing the highest straw yield. The partial budget analysis revealed that lantana vermicompost at 4 t/ha provided the highest marginal rate of return (43.02%), making it the most profitable treatment for farmers.

Based on the findings, several recommendations and areas for future research are proposed:

- Conduct long-term studies to monitor the sustainability and long-term effects of continuous application of lantana-based composts on soil health.
- Explore different application rates and combinations of lantana-based composts to identify the most efficient and cost-effective strategies for various crops and soil types.
- Extend the research to other crops to validate the benefits of lantana-based composts across different agricultural systems and crop types.
- Investigate the potential allelopathic effects of higher doses of lantana compost, as suggested by the reduced plant height at doses above 8 t/ha, to understand and mitigate any negative impacts.
- Study the microbial activity in the soil following the application of lantana-based composts to better understand the biological mechanisms driving the observed improvements in soil and crop performance

Declarations

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Competing Interests Statement

The authors declare having no competing interest with any party concerned during this publication.

Consent for Publication

The authors declare that they consented to the publication of this study.

Authors' contributions

All the authors took part in literature review, analysis and manuscript writing equally.

Availability of data and material

All data pertaining to the research is kept in good custody by the authors.

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